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TERTIARY FLORA OF NORTH AMERICA

United States Geological Survey of the Territories—Tertiary Flora. By L. Lesquereux. Vol. vii. (Washington, 1878.)

THE volume for the present year, of considerable thickness,[1] is entirely occupied by a most important work upon the Tertiary flora of North America. Although the geological and stratigraphical portions of the work are not so distinctly set out as they might have been, this by no means lessens the palæontological value of the work which is more especially in the author's province.

The country occupied by the Lignitic beds, described in the present volume, is a plain stretching for 600 miles between the Missouri and the Rocky Mountains. The ascending gradient is not more than ten feet per mile and the beds are horizontal; the whole Lignitic series is therefore exposed in sequence from east to west, commencing with the Cretaceous lignites, described in a previous volume (which occupy about one-third of the area), and ending with the newer Miocene or perhaps Pliocene beds.

The Tertiary Lignitic coal-fields of Western America alone, were estimated by Taylor in 1848 to occupy the enormous area of 250,000 square miles, or twice the area of Great Britain; but M. Lesquereux supposes that coal-beds of other ages must be included, and he points out (p. 7) that nothing positive was known of the great North American Lignitic until Dr. Hayden began his researches in 1854, and to the remarkable accuracy of whose work he pays a well-merited tribute.

Their area on the Upper Missouri is stated at not less than 100,000 square miles, and in the succeeding paragraph it is estimated at about 140,000 miles. This is their extent in that region of the United States alone, but their actual extent is much greater, since they stretch far across the border into British possessions; they have been traced southward along the base of the Laramie range to beyond the Arkansas River, and by outliers as far as Albuquerque, and again westward they are connected with the coal-fields of the Great Colorado Basin and the Laramie Plains.

Under the heading "Stratigraphy" we are told that there is no unconformability, physical, or other break in the sequence from the so-called Cretaceous lignites to the Tertiary Lignitic. It is then mentioned that there is a transition bed of coarse sandstone, irregularly deposited, whose thickness is not stated. There are next given detailed sections, some of Upper and some of Lower Lignite, none of them, however, presenting a thickness of more than 480 feet. It is strange that only a small paragraph (p. 12), extracted from Hayden's Report in 1874, to which no prominence is given, warns us that the Lower Lignites are of vast thickness—3,000 to 5,000 feet, but whether this thickness is all of Tertiary or the older lignites we are left to ascertain elsewhere, whilst we only incidentally gather that there is an Upper and a Lower Lignite. The faulty construction of the introduction arises from M. Lesquereux having too loosely strung together extracts from various works, which render it so disconnected as to be all but useless except to those who possess a previous knowledge of the subject. The thickness of, and as far as possible, the area occupied by, each division of the Lignite should have been as clearly set out as we find them in Hayden's Report for 1874, which is frequently referred to in the present work.

The third section is almost wholly occupied by verbatim extracts from the arguments of Professors Hayden, Meek, and Cope as to the age of the Lignitic. The conflicting nature of the evidence is apparent, the balance, apart from the botanical evidence, not here referred to, being decidedly in favour of Tertiary age. In the seventh chapter of the Annual Report, 1874, Peale had already given, in tabulated form, the views of authorities in regard to the age of each group of the Lignites which have been referred to Tertiary. In a much condensed form this might have been introduced into the present work with advantage. None of the Lignitic freshwater mollusca have been specifically identified with foreign forms; the vertical distribution of these being well-marked and limited, the evidence they would present should be of great value.

In this section (p. 24) a table is introduced incidentally, showing four groups of strata, which, omitting the lithology, the column of localities and all mention of fossils other than vegetable, reads thus:—

Names.	Fort Union group; Lignite group.	Wind River deposits.	White River group.	Loup River beds.
Sub-divisions.	"Great number of dicotyledonous leaves, stems, &c.; *Platanus*, *Populus*, &c.; with very large leaves of true Fan Palms."	"Petrified wood."	"Petrified wood."	[No vegetable remains mentioned.]
Thickness.	2,000 feet or more.	1,500 to 2,000 feet.	1,000 feet or more.	300 to 400 feet.
Foreign equivalents.	Eocene.	?	Miocene.	Pliocene.

From this table we should certainly conclude that the leaf remains were confined to the "Lignite group," and consequently that the botanical part of the work referred only to fossils of Eocene age. The work being on the "Lignitic" we are still further confirmed in this opinion, and dismiss the overlying "deposits," "group," and "beds" from our minds. With this impression we come to "Part II. *Description of the Tertiary Fossil Plants*," and are in no way prepared for such a surprise as is reserved for us in Part III., 273 pages further on, on finding that the leaves are figured and described from beds of Eocene, Miocene, and Pliocene age indiscriminately.

In the second and third parts M. Lesquereux is evidently working at more congenial subjects, and deserves praise for the painstaking way in which he has described the material before him. The truism that all determinations based upon leaves alone are provisional and untrustworthy, has deterred English botanists from working at our Tertiary floras; and thus while we see magnificent works on this subject brought out in France, Germany,

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[1] About 330 pages and 65 plates.

Austria, Italy, Switzerland, and America, no work of any importance has appeared in England. But though they are so, this in no way lessens the value of descriptions and figures for the purpose of comparing different floras, their distribution, the climatal conditions of each age, and inferring the relative age of isolated remains of land surfaces, volcanic outbursts, elevations, &c. It matters less whether a widely spread leaf-form is referred to oak or beech, than to ascertain that it is characteristic of a definite age and had a definite distribution. Fortunately there are palæo-botanists like M. Lesquereux who, having done their utmost to assign a leaf to its right genus, are content to wait for certain proof until the discovery of fruits and more perfect specimens.

Among the more interesting plants described are a *Lycopodium* and three species of *Selaginella*, all well preserved. The discovery of these is remarkable, as M. Lesquereux states that none of the Lycopodiaceæ had previously been known between Oolitic and recent times. The ferns are also of especial interest. Besides *Lygodium* and *Pteris* (which forcibly recall both Eocene and Miocene European forms), we have in *Gymnogramma Haydenii*, from the Lower Lignite, a form also common at Bournemouth (now described from more perfect fronds as an *Anemia*), and to the Aix-la-Chapelle flora as *Asplenium Forsteri*, Deb. and Ett., and to Sézanne as *Asplenium subcretaceum*, Saporta. Conifers and palms are numerous, but being fragmentary are less easy to compare with those of other localities. Still less so are other Monocotyledons, except a single Miocene *Smilax* leaf identified with a European species.

The Dicotyledons are very numerous, 212 species being described. Of these the leaves ascribed to *Myrica*, a large group mostly from the Upper or Miocene series, have an Eocene aspect. The forms assigned to *Betula*, *Alnus*, *Carpinus*, *Corylus*, and *Fagus*, are very similar to each other, and appear, from the figures, to have perhaps been too much subdivided. Any of these might be identified with leaves from Bournemouth, where the beds are undoubtedly Eocene. The leaf-forms from the Lower Lignite described as oaks have been determined with considerable hesitation, and are of most dissimilar character, as we see indicated by such specific names as *Q. platinia*, *Q. viburnifolia*, *Q. negundioides*. They have been classed as oaks on account of greater or less resemblance to species so described by European authors holding very diverse views. The single *Castanea* is indistinguishable from an Alum bay-leaf. In the simple forms of the Saliciniæ we have perhaps the nearest approach in character to European forms, and a large proportion of them will be found identical with leaves from Bournemouth. We must not, however, attach undue importance to the apparent similarity of simple ovate or lanceolate leaves, especially when comparisons are made from drawings only. The poplars form a large group, but, considering the variability of their leaves, species appear to have been unnecessarily multiplied, some being determined from fragments of leaves and others from single specimens, as *P. melanarioides*, *P. melanaria*, &c. *P. Zaddachi* is a familiar leaf in the English Bagshot and Woolwich beds, and in the Arctic beds, so-called Miocene; *P. Richardsoni* also appears identical with this form. Leaves, so similar to each other in outline and variation, that from the plates they can scarcely be distinguished, are described respectively as *Quercus platania*, *Populus lævigata*, and *Platanus Raynoldsii* and we long to know why they are so distinctly separated. The only leaf ascribed to *Ulmus* is from the Miocene stage, but appears identical with a Bournemouth form. Again *Quercus acrodon*, *Planera Ungeri* and *Fagus feroniæ* could all be matched with leaves from Bournemouth, and so resemble each other that it appears strained to have separated them under three genera and to form two new species from such material. On the other hand, one of the five figures (Fig. 5, pl. 28) ascribed to *Ficus lanceolata* is quite distinct from the rest and is certainly not that species, but a common British Eocene form. *Ficus multinervis*, Heer, is one of our most abundant Eocene plants, and, as suggested by Saporta, is more probably a *Laurus*. Leaves referred to *Ficus oblanceolata*, Lesq., analogous to another of our species, might reasonably have been separated as two species. As a group, the leaves called Ficus remind us of those met with in the Eocene. A remarkable feature in the flora is, that but a single form is referred to the Proteaceæ, and from its characters it seems unnecessary to refer even this to that group. Of the Lauriniæ, *Laurus* has an Eocene aspect, whilst the species of Cinnamonum appear correctly identified with Miocene forms. The nine species of *Viburnum*, which would perhaps have been better reduced to two, are analogous to a Bournemouth leaf, but still more so to the *Viburnum* of Sézanne. A leaf referred to the Australian genus, *Callicoma*, is of simple lanceolate form, with serrated edge, whilst two other forms referred to *Ericaceæ* are very indistinctly characterised. Many of those named *Sapindus* and *Diospyros*, as well as *Zizyphus* and *Rhamnus*, are of essentially Eocene facies and very similar to Bournemouth forms. The leaves placed together as *Ilex dissimilis* are so unlike that it seems doubtful whether they could have belonged to the same species.

The apparent defects which are here pointed out, may be partly due to imperfect figures, and reference to the specimens themselves might uphold the correctness of M. Lesquereux's separate determinations, since the specific identity or otherwise, of leaf forms, is often, after all, very much a matter of individual opinion.

The third part of the work contains a tabulated list of all the plants with the relative position of the beds from which they are derived, and also their possible relationship to those of the Eocene and Miocene strata of Europe. This is followed by a careful digest of the matter contained in the work, from which the following important facts are to be gathered. The lower group contains 200 out of the 325 species described, and is so isolated that but sixteen of the forms pass into the higher tertiaries, and these include none of the essential types, as the palms, magnolias, *Grewiopsis*, *Viburnum*, *Rhamnus*, &c. The second group has thirty-four species, twenty peculiar to it, and is, on the whole, correlated rather with the overlying Miocene than with the Lower Lignitic. The third group is unhesitatingly pronounced to be Middle Miocene, on account of the relation of its plants to the so-called Miocenes of Alaska, Greenland, Spitzbergen, and Europe; and it is further said that no Eocene type is present in the group. The fourth group is also

Miocene, and indicates a temperate climate such as that now prevailing in the middle zone of the United States, as from Ohio to North Alabama. The larger number of its species are identified with, or analogous to, those of Greenland, Spitzbergen, and Alaska, whilst a few are related to Pliocene plants, and three species are still living. Mr. Lesquereux devotes the concluding pages of his work to proving the Tertiary age of the Lignitic series. If, as he states, he has correctly ascertained that, in the first or lowest group, 120 species represent Tertiary, and only six can be considered at all as Cretaceous forms, he has made good his case, and all European palæontologists will agree with his views as to the age of the Lignitic.

The study of a very large series of British Eocene plants in my own collection, from well-defined horizons, has enabled me to draw somewhat different conclusions from those of Lesquereux and Heer. Unfortunately no great and undoubtedly Eocene flora has ever been described or published, and I therefore use the Bournemouth as a typical Eocene flora. The flora of Œningen, made so familiar to us by Heer, is a typical Miocene flora, and although most unlike a true Eocene flora, contains many plants common to other isolated fragments of strata which contain mixed floras, that is, floras with percentages of Eocene as well as Miocene plants. There being no typical series from the Eocene available as a standard of comparison, the plants common to the Miocene have alone been taken to determine the age of these beds, and the unknown Eocene forms have thus been enrolled as Miocene, and in their turn used to identify other still more distinctly Eocene beds as Miocene; much in the same way as the Barton beds were formerly identified, from their possessing a few species in common, as London clay, and the species peculiar to the Barton horizon subsequently made use of to identify Calcaire-Grossier and Bracklesham beds in their turn with the London clay. The errors which have thus possibly been committed even by Heer, who has been led to class all the many floras he has so ably described, either as Cretaceous or Miocene, were therefore unavoidable, and scarcely reflect upon his judgment.

The Lower Lignite is, in my opinion, undoubtedly Eocene, and probably contemporaneous with our London Clay or Lower Bagshot. The sudden incoming of palms and European plants of tropical kinds, and of mammals, and the displacement of the indigenous and temperate flora and of the lingering Dinosaurians, is evidence clear and unmistakable, that the continents became united at this period. Simultaneously with this sudden increase of temperature in America we find a corresponding increase in Europe, as seen on comparing together the faunas of the Thanet Sands and London Clay. The increase was in all probability due to the final rise of a land barrier completely shutting out all the cold northern currents, which at the present day set towards the equator, and so materially modify the ocean temperature. I think we are thus able to fix the comparative age of the Lower Lignitic, which, being upwards of 2,000 feet thick, probably required a great part of our Middle and Upper Eocene period for its deposition. I regard the second group as of our Upper Eocene age, and the third and fourth groups as Miocene.

Now comparing Dicotyledonous leaves of the Lignitic flora with those of Arctic regions, we find several, even of those from the Lower Lignite, common to both. The greater part of these are included in the following list:—

Viburnum Whymperi, Heer.
Fraxinus denticulata, Heer.
Diospyros brachysepala, Al. Br.
Andromeda Grayana, H.
Cissus tricuspidata, H.
Vitis Olriki, H.
Ficus tiliæfolia, Al. Br.

We find common to the Lower Lignitic and the Miocene of Switzerland—

Quercus neriifolia, Al. Br.
,, *chlorophylla*, Ung
,, *Godeti*, H.
Salix angusta, Al. Br.
Populus melanaria, H.
,, *mutabilis*, H.
Ficus tiliæfolia, Al. Br.
Cinnamonum Scheuchzeri, H.
,, *polymorphum*, Al. Br.
Daphnogene anglica, H.
Diospyros brachysepala, Al. Br.
Cornus Studeri, H.
Berchemia multinervis, Al. Br.
Rhamnus alaternoides, H.
,, *rectinervis*, H.
,, *Rossmässleri*, Ung.

or far more than sufficient to have identified the formation with Miocene had its true position not been otherwise ascertainable. None of these are, however, very distinctive leaves, and, with very few exceptions, they might, had the English Eocene Flora been published, have been referred to it with greater approximation to certainty. The exceptions are of little value, *C. Scheuchzeri* being identified on half a leaf, while the references to *P. mutabilis* and *C. polymorphum* are extremely doubtful. The truth is that so many of the ovate and lanceolate leaves of the Miocene and Eocene resemble each other that it would be easy to compile a sufficient list to refer, with plausibility, any given flora to either age, according to the author's fancy.

I have not yet had leisure to enter more minutely into the question, but it appears to me that the fact of a proportion of the Lower Lignitic leaves, which are of undoubted Eocene age, being also found in the Arctic floras, and the untrustworthy nature of the evidence on which these have been referred to Miocene, still leaves the question of their true age, on palæo-botanical evidence, unsettled. We know that in Eocene times these regions were land, and that floras existed upon them, and passed from one continent to the other, whilst in Miocene times, from the decrease in temperature, we infer that the submergence of this bridge had commenced. Further, the high temperature in the Eocene time would have permitted a temperate flora to grow in these latitudes, and the Miocene temperature would not. Lastly, it is difficult to conceive that the same quality of flora could have grown contemporaneously in latitudes so widely different as the United States and Greenland or Spitzbergen, but there is no difficulty in realising that a decreasing temperature, such as prevailed in the Miocene would have gradually driven the northern forms southward, and thus the very similarity of the Miocene flora of America to that of the Arctic circle renders it unlikely that they were of the same age. J. S. GARDNER